REVIEW
RFMV 2020

Highlights from the Respiratory Failure and Mechanical Ventilation 2020 Conference

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ABSTRACT The Respiratory Intensive Care Assembly of the European Respiratory Society organised the first Respiratory Failure and Mechanical Ventilation Conference in Berlin in February 2020. The conference covered acute and chronic respiratory failure in both adults and children. During this 3-day conference, patient selection, diagnostic strategies and treatment options were discussed by international experts. Lectures delivered during the event have been summarised by Early Career Members of the Assembly and take-home messages highlighted.

@ERSpublications
During #RFMV2020, patient selection, diagnostic strategies and treatment options were discussed by international experts. This review summarises the most important take-home messages. https://bit.ly/3murkoa

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Introduction

A detailed understanding of respiratory physiology is the foundation of adequate patient management, as highlighted in the opening session by Martin Tobin, Leo Heunks and Stefano Nava.

Martin Tobin first gave a historical perspective on respiratory medicine. He presented how the principles of mechanical ventilation were described in the 16th century; however, they are reportedly alluded to in the Old Testament of the Bible. Mechanical positive pressure ventilation further developed in the 18th and 19th centuries with bellow ventilation, but was thought to be deleterious because of pneumothoraxes. Negative-pressure ventilation was invented in the second half of the 19th century and was the main method of delivering mechanical ventilation during the poliomyelitis epidemic in Copenhagen. Prof. Tobin remarked that intensive care medicine began during this pandemic thanks to Bjørn Ibsen, an anaesthesiologist who recognised that polio was causing respiratory acidosis and treated patients with positive-pressure ventilation delivered through tracheostomy [1]. This lecture was particularly enlightening given the imminent declaration of the severe acute respiratory syndrome coronavirus 2/coronavirus disease 2019 pandemic.

Leo Heunks provided an overview of the neural respiratory drive and its three feedback mechanisms: chemical, cortical and reflex, both in healthy subjects and pathological states. As neural drive can preclude lung-protective ventilation, he described how it can be evaluated. Furthermore, he described how neural drive is influenced by propofol sedation, opioids, extracorporeal carbon dioxide (CO_2) removal and adjustments in ventilator settings. The importance of understanding respiratory mechanics was highlighted, as this has direct consequences for lung-protective ventilation strategies. In addition to plateau pressure, the importance of the driving pressure on the onset of ventilator-induced lung injury was highlighted.

Stefano Nava closed the session with an overview of the mechanisms of hypoxaemia including 1) alveolo–capillary diffusion limitation, 2) ventilation/perfusion mismatch, 3) hypoventilation, 4) shunt and 5) reduced inspired oxygen tension. He showed how these mechanisms are implicated in respiratory diseases. He stressed that the understanding of these mechanisms was important to deliver adequate ventilatory support to patients.

Take-home message

Understanding the physiology of respiratory disease and the principles of ventilation is key to delivering optimal clinical care.

Acute respiratory failure

High-flow nasal therapy and noninvasive ventilation

Hypoxaemic acute respiratory failure

High-flow nasal therapy (HFNT) is widely applied to treat hypoxaemic acute respiratory failure in clinical practice, despite currently limited data on patient selection, settings and monitoring. HFNT may improve oxygenation, reduce respiratory rate and work of breathing compared to conventional oxygen [2]. However, its effect on intubation risk appears to be dependent on the aetiology and severity of acute respiratory failure [3–5]. The ROX (respiratory rate and oxygenation) index (respiratory rate to peripheral oxygen saturation/inspiratory oxygen fraction (F_{IO_2}) ratio) may be used to predict HFNT failure and avoid intubation delays [6].

Noninvasive ventilation in acute hypercapnic respiratory failure

Noninvasive ventilation (NIV) is established in the management of acute hypercapnic respiratory failure [7] and reduces mortality, admission duration and healthcare costs compared to invasive ventilation [8]. It can be delivered on general wards, high-dependency and intensive care units [9–11]. However, staff experience predicts success [12] as does adequate patient selection. Early recognition of treatment failure is crucial to avoid delayed intubation [13]. Helmets, which require higher pressure support [14], are increasingly applied [11], with no observed differences in treatment success compared to oronasal masks [15].

Noninvasive ventilation in acute hypercapnic respiratory failure in non-COPD patients

Prospective randomised trials on NIV in obesity-related acute hypercapnic respiratory failure are lacking. Morbid obesity, pneumonia and multiorgan failure may predict treatment failure [16], and endotracheal intubation must be readily available [17]. Post-discharge domiciliary NIV or continuous positive airway pressure may reduce short-term mortality [18]. NIV may also be effective in acute hypercapnic respiratory failure in a range of neuromuscular diseases [19, 20] and as a bridge to lung transplantation in cystic fibrosis [21].

HFNRT in acute hypercapnic respiratory failure

HFNT prolongs expiratory time and decreases respiratory rate and work of breathing in stable hypercapnic patients [22]. Trials evaluating its effects in acute hypercapnic respiratory failure compared to NIV [23] and during acute hypercapnic respiratory failure breaks compared to conventional oxygen are ongoing [24]. To date, there are insufficient data to support its routine application in clinical practice. Data on HFNT physiological and clinical effects in acute hypercapnic respiratory failure, patient selection and settings are needed to guide clinical practice.

NIV use post-extubation

Extubation failure increases mortality and duration of hospitalisation [25]. Systematic application of post-extubation NIV may increase mortality, probably due to delayed reintubation [26, 27]. However, among high-risk patients (older age, hypercapnic during spontaneous breathing trial, chronic lung disease, surgical), NIV can prevent post-extubation acute hypercapnic respiratory failure and reintubation [28–31], particularly when administered with HFNT [32].

NIV in palliative care

NIV may be offered to palliate breathlessness in life-limiting disease [7, 33, 34]. It may reduce opiate requirements [35] without impairing quality of life [36, 37]. However, risks of distress from alarms, prolonged hospitalisations for training and impaired communication and oral intake must be anticipated. Alternative therapies, including mechanical insufflation–exsufflation, HFNT and Tai Chi may be considered [38]. Planned NIV withdrawal to alleviate distress may be performed with analgaesia/sedation and oxygen at home or in hospital [39].

Take-home messages

- HFNT may be used to improve oxygenation in hypoxaemic acute respiratory failure.
- Following careful patient selection, NIV is an effective therapy for hypercapnic respiratory failure and improves a range of clinical outcomes.
- Patients receiving HFNT and NIV must be monitored closely by experienced staff for signs of treatment failure.

Adverse effects of mechanical ventilation

Mechanical ventilation is key for the management of severe acute respiratory failure, but can also have adverse effects that need to be monitored.

Heart–lung interaction

Positive-pressure ventilation has both beneficial and adverse effects on the cardiovascular system. Positive-pressure ventilation changes lung volumes, and more importantly, increases intrathoracic pressure. The intrathoracic pressure has an important influence on venous return, a major determinant of cardiac output. Positive-pressure ventilation decreases pre-load, increases right ventricular afterload (increased pulmonary vascular resistance) and decreases left ventricular afterload. Hence, mechanical ventilation can induce right ventricle dysfunction. Physicians should also take into account right ventricle function in order to set positive end-expiratory pressure (PEEP) according to right ventricle function [40].

Ventilator-induced lung injury

Lung injury in patients on mechanical ventilation is closely related to ventilator settings. Indeed, ventilation set at low lung volumes can cause atelectrauma, whereas ventilation set at high lung volumes can lead to overdistension and barotrauma [41]. There is convincing evidence for benefit of ventilation with a low tidal volume in patients with acute respiratory distress syndrome (ARDS). Such benefit may also be seen in patients without ARDS [42–44]. Female patients with ARDS tend to have higher mortality due to higher tidal volume (per predicted bodyweight) compared to males [45, 46].

Ventilator-induced respiratory muscle injury

Mechanical ventilation can injure the respiratory muscles as well as the lungs. Diaphragm dysfunction occurs very frequently in the intensive care unit (ICU) and results from different mechanisms related to the consecutive time points in the disease course of the ventilated patient. It is associated with weaning failure and decreased survival [47]. Ultrasound of the diaphragm may be helpful in monitoring diaphragm function and effort in the ICU [48].

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Long-term consequences of mechanical ventilation

Critical illness leads to multimorbidity ranging from functional impairment caused by muscle weakness to neurocognitive dysfunction and mood disorders associated with diminished quality of life [49–51]. Critical illness affects patients and their families. Caregivers are at high risk of mood disorders and increased mortality [52]. Attempts should be made to identify at-risk patients and caregivers and long-term risk assessments should be part of standard care. An integrated post-ICU care pathway across the care and recovery continuum should be a new practice standard to meet complex patient and caregiver needs after critical illness [53].

Take-home messages
- Ventilator-induced lung injury can be limited by careful selection of lung-protective ventilation.
- Diaphragm-induced injury develops frequently and may be limited by monitoring effort, for instance with diaphragm ultrasound.
- Critical care survivors and their caregivers may suffer from long-term sequelae that should be monitored.

Rescue therapies for respiratory failure

Lung recruitment manoeuvres or prone positioning

Lung recruitment manoeuvres are typically performed by temporarily increasing airway pressure.

A recent trial performing a lung recruitment manoeuvre and subsequent PEEP titration in ARDS resulted in increased mortality [54]. Therefore, recruitment manoeuvres should only be used as a rescue therapy and not as a routine manoeuvre in patients with hypoxaemic failure. The use of higher PEEP compared to lower PEEP failed to show a benefit on mortality [55–57].

Prone positioning is another method that aims to enhance lung recruitment, and as such homogenise the lung in patients with ARDS. A more homogenous lung is less likely to be affected by shear stress and atelectrauma during tidal breathing. The study by Gattinoni *et al.* [58] on prone positioning in ARDS showed no survival benefit. However, a randomised controlled study with more prolonged prone positioning (>16 $h \cdot day^{-1}$) showed improved survival [59, 60].

Extracorporeal CO_2 removal

From a physiological perspective, arterial carbon dioxide tension (P_{aCO_2}) reduction leads to respiratory muscle unloading. Extracorporeal CO_2 removal may be used in COPD patients to avoid intubation as rescue therapy after NIV failure or to facilitate weaning. However, robust data supporting its use in daily clinical practice are currently lacking.

Extracorporeal membrane oxygenation

Two large randomised controlled trials have evaluated extracorporeal membrane oxygenation (ECMO) in patients with severe ARDS. The CESAR trial showed an improved survival compared in patients referred to ECMO centres compared to treatment in non-ECMO centres [61]. The EOLIA trial did not show any improvement [62]. However, in this trial, the rate of crossover to ECMO was 28%. *Post hoc* analyses reported significant relative risk reduction with ECMO [63].

Take-home messages
- Prone positioning is effective in improving survival in patients with moderate-to-severe ARDS (arterial oxygen tension/F_{IO_2} ratio <150 mmHg).
- The use of extracorporeal CO_2 removal needs to be supported by randomised controlled trials.
- ECMO may improve survival in patients with severe ARDS.

Diagnostic techniques

Lung ultrasound

Lung ultrasound is an appealing bedside diagnostic tool, since it is a safe, easy-to-learn, fast, accurate, repeatable and real-time technique that avoids ionising radiation exposure and transfer-related risks. Lung ultrasound requires a simple machine and any probe may be used. Both eight- and 12-zone scanning approaches are generally adopted.

There is evidence for usefulness and accuracy of lung ultrasound in diagnosing interstitial syndrome, consolidation, pneumothorax, pleural effusion and acute respiratory failure. In addition, lung ultrasound is suitable for monitoring aeration changes and effect of treatment in the critically ill. However, it has limitations in detecting small lesions and in patients with subcutaneous emphysema/oedema, obesity, large dressings, bandages and drains.

Oesophageal pressure monitoring

The measurements of oesophageal pressure (P_{oes}) is minimally invasive in mechanically ventilated patients. P_{oes} estimates transpulmonary pressure and the intensity of patient breathing effort [64].

P_{oes} measurements enhance our understanding of the pathophysiology of ARDS, patient–ventilator interaction and weaning failure [64]. There is emerging evidence that supports the use of P_{oes} in patients with ARDS [65].

Bronchoscopy in mechanically ventilated patients

Bronchoscopy in invasively ventilated patients allows inspection of the airway, sampling and treatment (such as foreign body removal). However, it can also have detrimental consequences (table 1). Given the frailty of patients with ARDS and given the possible complications, bronchoscopy should only be performed following care consideration of risks and benefits. Expected benefits will be assessed using the diagnosis hypothesis, considering alternative noninvasive diagnostic tests, the immunological status of the patient and risks of infection.

Take-home messages

- Lung ultrasound is an easy, safe way to assess lung parenchyma and pleural space at the bedside.
- P_{oes} measurements help to understand pathophysiological changes and aid decision making to improve ventilatory support.
- Benefits and risks must be assessed before performing bronchoscopy in invasively ventilated patients.

Year in preview in acute respiratory failure

Marcus Schultz identified five paradigm shifts that will influence research in acute respiratory failure in the coming years.

The first paradigm shift is to move from "mad physiology" to evidence-based logical thinking. For years we have tried to "restore" clinical parameters of critically ill patients to match healthy subjects; for example, the arterial blood gas parameters of ARDS patients can be brought to near-normal levels by administering high tidal volumes, but mortality goes up drastically [66]. Instead, perhaps we should rest the lung to minimise mortality [67].

The second important paradigm shift is to incorporate personalised medicine in our trials and treatments. Trials on PEEP-setting might be beneficial if we can differentiate recruitable from non-recruitable patients, as opposed to giving large groups of heterogeneous patients the same level of PEEP [68]. Patients with ARDS might have different disease phenotypes (focal *versus* non-focal) that might require different treatment [69]. Computed tomography scans, lung ultrasound or labs-on-a-chip are exciting techniques to differentiate ARDS phenotypes. The same principle might even apply to sepsis.

The third paradigm shift is to stop thinking about the lung as a sterile environment, and to further study the importance of the lung microbiome. Several studies have observed associations between the lung microbiome and ICU outcomes [70]. Conversely, several interventions that optimise the lung microbiome have shown promising results [71, 72].

The fourth paradigm shift is to evaluate whether we treat females and males equally well. Recent retrospective analyses have found that females tend to receive higher tidal volumes, which might have detrimental effects on outcome [73].

TABLE 1 Physiological consequences of bronchoscopy

Respiratory consequences	Circulatory consequences	Other consequences
Increased airway resistance Decreased lung compliance Impaired gas exchange	Decreased cardiac output Increased heart rate Increased pulmonary arterial pressure	Increased intracranial pressure

Lastly, physicians should be prepared to have smart algorithms assist them with various clinical tasks, such as managing the settings of the mechanical ventilator. This will allow the clinician to focus on other tasks.

Take-home messages
- Stop "mad physiology": critically ill patients do not need to be normalised.
- Differentiation of disease phenotypes can lead to personalisation of ICU treatment.
- The lung microbiome provides an exciting new target to prevent infections in ventilated patients.
- Sex differences in research and clinical care must be minimised.
- There is an emerging role for artificial intelligence in clinical practice and research.

Chronic respiratory failure

NIV in COPD patients

Patient selection

The use of home NIV to treat COPD patients was only recently supported by large-scale randomised controlled trials. A meta-analysis confirmed its efficacy in decreasing all-cause mortality and hospital admissions. However, health-related quality of life did not significantly improve [74]. Based on results from randomised controlled trials, home NIV should be used [75] in 1) stable severe COPD patients who have persistent hypercapnia in stable state [76] and 2) patients with severe COPD who were admitted for acute hypercapnic respiratory failure and who remained hypercapnic 2–4 weeks following discharge [77] (table 2). In these two trials, ventilation was set in order to significantly reduce daytime P_{aCO_2} (−0.5 kPa or −20%).

Take-home messages
- Home NIV reduces mortality in stable COPD patients with daytime P_{aCO_2} >52 mmHg/6.9 kPa.
- Home NIV increases time to readmission in COPD or death patients with daytime P_{aCO_2} >53 mmHg/ 7 kPa by 2–4 weeks following an episode of acute hypercapnic respiratory failure.

What are the targets?

NIV is set to reduce P_{aCO_2}. However, improvement in health-related quality of life or of sleep and in ability to perform daily life activities are more important for patients. Patient-centred goals such as sleep quality, sputum clearance, health-related quality of life, exercise capacity, survival and exacerbation frequency are improved with NIV [76–78]. Reduction of exacerbation and hospital admission are also meaningful targets, as they have a detrimental effect on disease course. Close monitoring of NIV tolerance should be conducted, as ventilation side-effects are frequent and may influence efficacy and adherence to the treatment. Good adherence to ventilation (>4 h·night^{-1}) is associated with better survival [79].

Take-home messages
- NIV must aim to improve meaningful patient-centred outcomes in addition to reducing P_{aCO_2}.
- Compliance to NIV needs to be monitored, as well as NIV-related side-effects.

TABLE 2 Overview of selection criteria for noninvasive ventilation (NIV) in patients with COPD

	Who?	When?	How?	Why?
Stable COPD	Severe stable COPD (FEV$_1$ <1 L) Baseline P_{aCO_2} >52 mmHg/6.9 kPa Preserved exercise capacity (6MWT >200 m) Low annual emergency admission rate	Stable state Low annual emergency admission rate	Targeted P_{aCO_2} reduction	Reduces 1-year all-cause mortality
Post-AECOPD	Severe COPD (FEV$_1$ <1 L) Following a life-threatening exacerbation of COPD requiring acute NIV Persistent hypercapnic respiratory failure defined by P_{aCO_2} >53 mmHg/7 kPa 2–4 weeks post-AECOPD	2–4 weeks post-AECOPD if P_{aCO_2} >52 mmHg	Targeted P_{aCO_2} reduction	Increases admission-free survival Cost-effective treatment

FEV$_1$: forced expiratory volume in 1 s; P_{aCO_2}: arterial carbon dioxide tension; 6MWT: 6-min walk test; AECOPD: acute exacerbation of COPD.

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ERS task force on long-term NIV in COPD [75]

In addition to defining patients in whom NIV should be initiated, the ERS task force suggested using high-intensity NIV with high inspiratory airway pressures (IPAP) instead of low IPAP, which is ineffective in reducing P_{aCO_2} and might even reduce health-related quality of life [80, 81].

NIV in patients with neuromuscular disease

Role of neuromuscular diseases in pulmonary medicine

As highlighted in the opening session, neuromuscular diseases (NMDs) such as poliomyelitis [1] are an important part of mechanical ventilation. Rose *et al.* [82] demonstrated the continued importance of NMDs, with an increasing prevalence and decreasing mortality in a national Canadian survey. Of all patients with a NMD, a third receive pulmonary input, with frequent comorbid airway disease [83].

The early studies by Simonds and co-workers demonstrated that survival was significantly longer in NMD patients compared with COPD [84] and that NIV categorically prolongs survival in the presence of hypercapnia in Duchenne muscular dystrophy [85]. Importantly, Kohler *et al.* [86] demonstrated that the introduction of NIV did not have a detrimental effect on health-related quality of life in patients with NMD.

Take-home messages

- NMDs are a common indication for initiation of NIV.
- NIV improves survival and quality of life in patients with NMD.

NIV in rapidly progressive NMD: when to start?

A prognostic model for death in amyotrophic lateral sclerosis was highlighted as a method to predict time of initiation [87]. Before initiation of ventilation polygraphy and/or capnography (figure 1) should be used

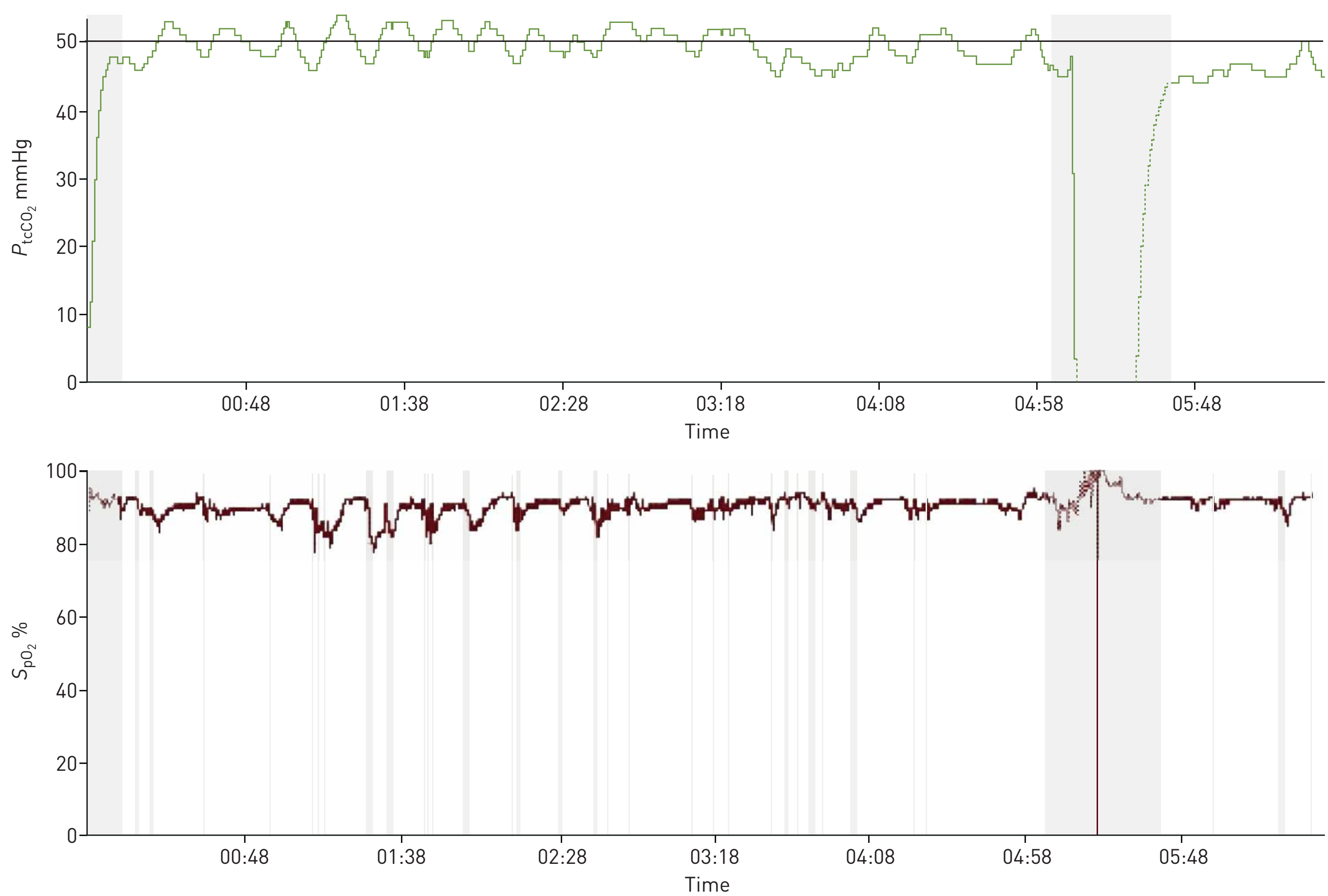

FIGURE 1 Overnight transcutaneous capnography during self-ventilation of a patient with type I myotonic dystrophy showing severe hypoventilation without rapid oxygen desaturation that would suggest obstructive sleep apnoea. P_{tcCO_2}: transcutaneous carbon dioxide tension; S_{pO_2}: peripheral oxygen saturation.

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to screen for hypoventilation, with polysomnography being reserved for unusual cases. An algorithm for setting up NIV in amyotrophic lateral sclerosis by Morélot-Panzini *et al.* [88] illustrated when and how NIV should be set up in patients with amyotrophic lateral sclerosis. In amyotrophic lateral sclerosis, there is noninferiority of daytime NIV set-up compared with conventional polysomnography set-up [89].

Take-home messages
- Overnight assessment is useful to adequately initiate NIV in patients with NMDs.
- NIV can be initiated as an outpatient in patients with NMDs.

Cough assistance

In patients with NMD, cough is frequently impaired and secretion clearance techniques are required [90]. The use of mechanical insufflation–exsufflation is effective at increasing peak cough flow [91], but fatigue is significantly increased immediately after therapy [92]. The physiological effectiveness of mechanical insufflation–exsufflation remains to be elucidated with more work needed on its effect on breathing pattern and lung mechanics [93, 94].

Take-home message
- Mechanical insufflation–exsufflation improves secretion clearance.

A year in review in chronic respiratory failure

Wolfram Windisch analysed three questions that will shape the future of chronic respiratory failure and long-term home ventilation [75].

The first is whether outpatient control of long-term noninvasive mechanical ventilation is feasible in COPD patients. Recent studies suggest that two-thirds of patients can be managed without hospitalisation [95].

The next question is whether NIV at home is beneficial after an exacerbation in COPD patients. Although this strategy improves arterial blood gases, studies have conflicting results regarding readmission rates, mortality and long-term quality of life [77, 96].

The final question was whether newer modes of mechanical ventilation are beneficial in the long-term home ventilation setting. Although there is a strong physiological rationale for newer modes, evidence so far has been conflicting.

Take-home messages
- Outpatient management of NIV in COPD patients is feasible, cost-effective and preferred by patients.
- More studies are required to decide the role of home ventilation after episodes of acute respiratory failure in COPD patients; better patient selection will increase the benefit of high-intensity home ventilation.
- Further study is warranted to increase the quality of life of patients receiving home ventilation.

Paediatric mechanical ventilation

Particularities

Managing respiratory failure and ventilation in paediatrics presents numerous and unique challenges due to heterogenous causes of respiratory failure, significant variation in age, size and respiratory mechanics of children, lack of appropriate equipment, ethical issues of long-term invasive ventilation when children cannot contribute to decision making and difficulties assessing quality of life.

These factors make extrapolating findings from adult clinical trials problematic; additionally, conducting large randomised control trials in children is challenging, leading to a lack of evidence to guide management. These complexities were highlighted, emphasising the lack of a "one guideline fits all" approach with illustrative cases. Sessions focused on lung-protective ventilation strategies in children, novel methods of optimising ventilation and use of long-term invasive and noninvasive ventilation in the home.

Lung-protective ventilation

Lung-protective ventilation strategies can be instituted from birth. Evidence-based recommendations for premature neonates include using gestation to guide choice of oxygen or room air during resuscitation and targeting normal post-natal saturations of preterm infants. Avoiding invasive mechanical ventilation is

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preferred where possible, with early use of continuous positive airway pressure and rescue surfactant administered by less-invasive surfactant therapy or minimally invasive surfactant treatment techniques that do not require intubation. Recommended mechanical ventilation techniques are volume-targeted/volume guarantee modes to limit volutrauma, particularly after rapid changes in compliance post-surfactant administration.

There may be an increased capacity of the paediatric lung for repair, possibly reducing vulnerability to ventilator-induced lung injury. Recommendations from the Pediatric Acute Lung Injury Consensus Conference included use of low tidal volumes adjusted for pulmonary compliance, maintaining inspiratory plateau pressure <28 cmH_2O and permissive hypercapnia for moderate-to-severe paediatric ARDS. Heterogenous causes of paediatric ARDS makes determining optimal PEEP difficult. Interestingly, Khemani *et al.* [97] showed that paediatricians often used lower PEEP than recommended by ARDSNet and this was associated with higher mortality. The role of NIV appears to be limited to mild paediatric ARDS.

The only paediatric randomised control trial of prone positioning was stopped early due to futility.

Take-home messages
- In premature neonates, invasive ventilation should be avoided if possible.
- Protective ventilation in paediatric ARDS differs from adult ARDS.

New modes of ventilation in acute respiratory failure

High-frequency oscillatory ventilation in paediatric ARDS has been shown to be associated with adverse outcomes, especially increased risk of air leak. Hopefully, the PROSPECT trial (Prone and Oscillation Paediatric Clinical Trial) will clarify the roles of high-frequency oscillatory ventilation and prone positioning in the management of paediatric ARDS.

Reducing the mechanical power applied to the lung during mechanical ventilation with ECMO and paying particular attention to very low tidal volumes, low respiratory rates and low plateau pressures may reduce lung injury, with different strategies for obstructive lung disease and early and late ARDS.

Neurally adjusted ventilation assist can be particularly useful in complex children with severe tracheomalacia, neuromuscular weakness, post-cardiac surgery and ECMO. It can be used to improve patient–ventilator synchrony with NIV.

HFNT is increasingly being used to treat acute respiratory failure in paediatrics, with the majority of evidence in infants with bronchiolitis. There is some evidence that it may be useful in other forms of acute respiratory failure, but has yet to be shown to be superior to NIV. Increasingly, HFNT is being used in the home for children unable to tolerate continuous positive airway pressure for obstructive sleep apnoea, particularly children with trisomy 21 and craniofacial disorders.

Take-home messages
- The use of neurally adjusted ventilation and high-frequency oscillatory ventilation is not supported by controlled trials.
- HFNT is widely used for the management of bronchiolitis.
- HFNT can be an alternative to continuous positive airway pressure.

The year in preview in paediatric mechanical ventilation

Brigitte Fauroux pointed out that many treatment recommendations and protocols in paediatric medicine are not based on evidence, but on expert opinion [98]. Several factors contribute to this problem. Many of the current recommendations in paediatric mechanical ventilation are based on studies conducted in the adult population [98]. However, the physiology of the paediatric population might differ substantially from adults. Paediatric researchers should focus on trials on lung-protective ventilation, assisted spontaneous breathing, NIV and weaning [99].

Recent trials in these areas have been promising, but require more validation in larger cohorts and in more countries and centres. For instance, a small single-centre study observed benefit for permissive hypercapnia [100]. The CALIPSO trial found that survival is not better when surfactant is administered to paediatric patients with lung injury [101]. Another study observed a staggering two-fold increase in mortality when using airway pressure-release ventilation *versus* conventional low tidal volume ventilation in paediatric patients [102]. Prone positioning (a trusted method in adults) was studied in paediatrics, and was found to increase lung homogeneity in one-third of the participants [103].

Lastly, the importance of sleep in the paediatric ICU is under-studied. This is troublesome, as lower sleep quality has been linked with susceptibility to infection and higher rates of failing spontaneous breathing trials [104]. Simple interventions such as better sound and light management might make a lot of difference for sleep quality and should be studied. Additionally, cerebral oxygenation during respiratory events might be of paramount importance for neurological outcomes and requires further study [105], possibly by using new techniques such as near-infrared spectroscopy [106].

Take-home messages
- Validation of opinion-based recommendations is paramount for evidence-based paediatric medicine.
- Trials in paediatrics should switch from "hard end-points", such as mortality, to more relevant outcome parameters, such as neurological development.
- The importance of sleep quality and cerebral oxygenation need to be studied further in paediatric medicine.

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